REMARKS

Claims 1, 2, 12, 17, 23 and 26-28 have been amended. Claims 1-30 remain in the application. Applicants reserve the right to pursue the original claims and other claims in this and other applications.

Claims 1-10, 12, 17, 23 and 26-29 are rejected under 35 U.S.C. § 103 as being unpatentable over Chu in view of Yasushi '253. Reconsideration is respectfully requested. Chu and Yasushi, even when considered together, fail to suggest all of the features of the claimed invention.

The present invention relates to particle beam irradiation equipment which can provide a long range charged particle beam within the patient body, and high dose uniformity at any irradiation field size. An explanation as to how these effects are achieved is provided in the present application, starting on page 30, and in particular, from page 33, line 26, to page 35, line 10, with reference to Figs. 5A and 5B.

According to one aspect of the invention, there are two types of second scatterers 32, 36, one type 36 being the scatterer used at a first position and another type 32 being the one used at a second position upstream of the first position, and the another type scatterer 32 is positioned nearer to the first scatterer 28 than the one type scatterer 36. Further, the another type scatterer 32 nearer to the first scatterer 28 is configured to provide a larger scattering strength of the charged particle beam than the one type scatterer 36 (by making the thickness larger than the one type scatterer 36, for example), while the one type scatter 36 is configured to provide a smaller scattering strength than the another type scatterer 32 (by making the thickness smaller, for example).

When a large irradiation field is to be formed, the another type scatterer 32 is used, so that the ion beam is irradiated in accordance with the characteristics plotted in the left-side regions of Figs. 5A and 5B. As indicated by, e.g., X_L in Fig. 5A, a long range can be obtained with a reduction of range loss. Consequently, as seen from Fig. 5A, the range length can be increased to a level comparable to a minimum value X_S of the range obtained

in the case of forming a small irradiation field. On this occasion, the deterioration rate of the dose uniformity is relatively increased, as indicated by, e.g., α_L in Fig. 5B. In spite of the increase, as seen from Fig. 5B, the deterioration rate of the dose uniformity can be held at a level comparable to a minimum value α_S of the deterioration rate obtained in the case of forming a small irradiation field.

On the other hand, when a small irradiation field is to be formed, the one type scatterer 36 is used, so that the ion beam is irradiated in accordance with the characteristics shown in the right-side regions in Figs. 5A and 5B. The deterioration rate of the dose uniformity can be reduced as indicated by, e.g., α_S in Fig. 5B. Consequently, as seen from Fig. 5B, the dose uniformity can be improved to a level comparable to a maximum value α_L of the deterioration rate obtained in the case of forming a large irradiation field. On this occasion, the range is relatively decreased to, e.g., X_S in Fig. 5A. In spite of the decrease, as seen from Fig. 5A, the range can be held at a level comparable to a maximum value X_L of the range obtained in the case of forming a large irradiation field.

Thus, regardless of whether a large irradiation field or a small irradiation field is formed, the range can be held at a comparatively large value as indicated by X_L or X_S, and not shortened while the deterioration rate of the dose uniformity can be held at a comparatively small value as indicated by α_S or α_L and prevented from increasing. In other words, irrespective of the field size, the second scatterer can be placed at an optimum position of balance between longer range and higher dose uniformity. As a result, the irradiation can always be realized at a long range and high dose uniformity over the whole of the practically formable irradiation field.

Recently, there has been a need for a larger size irradiation field. Equipment with an increased available maximum field size responsive to the need would be desirable. The present inventors found, however, that when the available maximum field size is increased in the equipment responsive to the need for a larger size of the irradiation field, a proper mount position of the second scatterer in the case of producing a comparatively large field size greatly differs from the proper mount position thereof in the case of

producing a comparatively small field size, so that it has been difficult to always realize irradiation with a long range and high dose uniformity regardless of the field size. The inventors also discovered that the problem can be solved by the present invention.

Chu discloses, in Fig. 36, charged particle beam irradiation equipment having a first scatterer, second scatterer, collimator and an occluding post and ring (occluder assembly) disposed between the first scatterer and the second scatterer. Further, Chu discloses in page 2082, right column, ". . . providing a different occluder system for each particle species and energy used is costly, and changing the systems each time the beam is changed is not practical in clinical operations. One way to resolve this problem is to vary the locations of the occluder assembly and the second scatterer . . . the occluder assembly may be moved upstream nearer to the first scatterer so that the projected radii at the isocenter are proportionally increased . . . ."

Thus, Chu suggests, as one way to solve the problem, to vary the locations of the occluder assembly and the second scatterer and explains that the occluder assembly may be moved upstream nearer to the first scatterer. However, Chu neither teaches nor suggests to vary the position of the second scatterer in the direction of travel of the charged particle beam. Further, Chu fails to suggest that one of the second scatterers caused to be positioned in the passage region at a first position in the direction of travel of the charged particle beam is configured to provide smaller scattering strength of the charged particle beam in a direction perpendicular to the direction of travel of the charged particle beam than another one of the second scatterers which is caused to be positioned in the passage region at a second position upstream of the first position in the direction of travel of the charged particle beam (the second scatterer located at the first position is thinner than the second scatterer located at the second position, for example).

Yasushi discloses, in paragraphs [0136] to [0139], charged particle beam irradiation equipment with three-dimensional spot scanning, in which a plurality of scatterers 19, 20, 21 are located in the direction of advance of the charged particle beam. In the irradiation equipment, one of the scatterers located in the direction of advance of

the charged particle beam is selected for changing the distance from the tumor to the scatterer to thereby change the beam size (diameter) at the position of the tumor and enable the beam size (diameter) to be enlarged. Yasushi does not teach that one of the second scatterers which is caused to position in the passage region at a first position in the direction of travel of the charged particle beam is configured to provide smaller scattering strength in a direction perpendicular to the direction of travel of the charged particle beam than another one of the second scatters which is caused to position in the passage region at a second position upstream of the first position in the direction of travel of the charged particle beam (the second scatterer located at the first position is thinner than the second scatterer located at the second position, for example).

Further, Yasushi aims to reduce the unevenness of dose distribution at the tumor caused by change in the beam size or diameter at the tumor influenced by the thickness of the selected range shifter (absorber) in the three dimensional spot scanning, and to this end, Yasushi would select an appropriate scatterer among the scatterers disposed in the direction of advance of the charged particle beam and place it across the beam pass to thereby correct the beam size. The present invention, in contrast, contemplates providing a long range of a charged particle beam in the patient body and ensure high dose uniformity at any irradiation field size, when the charged particle beam shaped by the collimator is applied to the tumor. Thus, Yasushi also differs from the present invention in the underlying concept of the invention.

Claims 11, 13-16, 18-22, 24, 25 and 30 should be allowable along with claims 1-10, 12, 17, 23 and 26-29, and for other reasons. For at least the foregoing reasons, allowance of the application with claims 1-30, as amended, is solicited.

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Respectfully submitted,

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